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ASSESSMENT OF POTABLE WATER OF SPRINGS USED IN AND AROUND SHILLONG AREA, MEGHALAYA, INDIA

Pradeep Das [1] | Mahananda Borah [2] | Sorat Konwar [2] | Manabendra Nath [3] | Pradip Kumar Das [4]

[1] Department of Environmental Management, Dimoria College, Khetri, Assam, India.
[2] Department of Geology, Dimoria College, Khetri, Assam, India.
[3] Department of Geology, G.C. College, Silchar, Assam, India.
[4] Department of Geology, Cotton College State University, Assam, India.

ABSTRACT

A pioneer study was made from the different localities in and around Shillong area for assessment of potable water of springs used by most of the residential people of Shillong. Physico-chemical and Biological parameters of water quality monitoring was carried out for the different water samples collected from spring water source. The results of different parameters are incorporated in this paper. These show that most of the parameters are found water permissible limit except a few.

KEY WORDS: Physico-chemical and Biological parameters, Spring potable water, Shillong.

INTRODUCTION

Water of good drinking quality is of basic importance to human physiology and man's continued existence depends very much on its availability. The Provision of potable water to the rural and urban population is necessary to prevent health hazards. Before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards, which are designed to ensure that the water is potable and safe for drinking. Potable water to be free from diseases producing microorganisms and chemical substances detrimental to health. Water can be obtained from a number of sources, among which are streams, lakes, rivers, ponds, springs and wells. Unfortunately clean, pure and safe water only exist briefly in nature and is immediately polluted by prevailing environment factors and human activities. Water from most sources is therefore unfit for immediate consumption without some sort of treatment (Raymond, 1992). Consequent to the realization of the potential health hazards that may result from diseases to the contaminated drinking water. Contamination of drinking water from any sources is therefore of primary importance because of the danger and risks of waterborne diseases (Edems et al., 2001.

Shillong being a hill area, water is a scarce commodity in the absence of a major river or rich ground water aquifers. Like other Indian cities Shillong too faces acute water crisis during dry season. The large section of the people does not have access to water supply and those having access to water supply and those having access too are facing shortage and using contaminated water as water supplied is polluted with their own waste (Singh, 1986)

A spring can occur if impermeable bedrock prevents downward flow. The size of upslope area, the soil thickness, and the frequency of precipitation (rain or snowmelt) will determine whether the spring flows year-round.

The study area is located in Shillong, the capital of Meghalaya and the headquarter of East Khasi Hills District, Meghalaya. Shillong is situated along the northern slope and foot hill of the Shillong peak at Latitude 25034/N and Longitude 91053/E at an average altitude of 1496 meters above MSL and covers an area of 25.40 sq. The study area roughly lies between Lat. 25034/N-25024/N and Long 91053/E-91065/E. (Fig. 1)

In the North-Eastern region, Kumar et al (2006) have studied the quality assessment of potable water in the town of Kolasib, Mizoram. Water samples were analyzed for their physico-chemical and bacteriological characteristics in order to obtain the quality level of the potable water in town. The samples were collected from two different sources, i.e., the supply from the government agency Public Health Engineering Department (PHED) and from the naturally occurring springs. The results suggested that the water supplied by the PHED was better than the springs; however, the quality of water from both sources, which are used for drinking and domestic purposes, were found to be more or less within the tolerance limits.

MATERIALS AND METHODS

A preliminary survey was carried out along the localities of Shillong area to select the different sources of potable water, and to determine the sampling sites in such a way to get the representative water quality data for the whole location (17 stations). Physico-Chemical and Biological parameters of water quality monitoring were carried out for the different water samples in order to assess the quality of potable water used by the residents of Shillong area. The details of the same are provided below:

Water samples were collected during the month of March-April, 2014. On each sampling occasion, samples were collected separately for estimation of physciochemcial parameters, estimation of dissolved oxygen and total coliform bacteria. Water samples were collected in three different types of containers from each site i.e. in a plastic container of 1.5 litres capacity, in BOD bottles of 300ml for estimation of dissolved oxygen and in 250ml sterilized bacteria bottle for estimation of total coliform bacteria. On each sampling occasion, the water was allowed to flow for two minutes before collecting the samples from the source. The samples were appropriately labeled immediately after collection.

The collected samples were analyzed for major physical, chemical and biological water quality parameters like pH, Temperature, Electrical Conductivity (EC), Turbidity, Alkalinity, Chloride (Cl), Nitrate (NO_3), Iron (Fe^{3+}), Magnesium (Mg^{2+}), Calcium (Ca^{2+}) Total Dissolved Solids (TDS), Dissolved Oxygen (DO) and total Coliform Bacteria as per standard methods (APHA, 1995.)

Some of the important locations are shown here. (Fig. 2-5)

Physico-Chemical Parameters and their results:

Water Temperature:

For determination of water temperature, a mercury thermometer was used. While taking the reading the scale of the thermometer was immersed in the surface water up to the level of mercury in the capillary column of 3-5 minutes.

The study of water temperature in all the sites of Shillong City varied between 15.5^0c-17.1^0C. During the study, it was observed that the minimum temperature found was 15.5^0C at Station 3 (Bishnupur, Last Stop) and the maximum temperature found was 17.1^0C at Station 16 (Happy Valley). (Table 1)

pH

pH was measured using Digital pH Meter. Water samples were taken in a beaker and an electrode was immersed in the beaker containing the water sample and reading was taken accordingly.

The data of variation of pH is depicted in Fig 6 and Table 1. The pH of water samples found in the sampling sites varied between 5.5 – 7.0. The highest pH value 7.0 was observed in Station 14 (Dreamland) and the lowest 5.5 was found in Station 5 (Lawmali) Station 6 (Jail Road) and Station 15 (Lady Kane College.

During the study, it was found that the pH of water samples of Lawmali Jail Road and Lady Kane College was found to be slightly acidic with the value of 5.5 and the pH of Polo, Laban (Civil Hospital), Laitumkhrah, Bishnupur, Bonphail road, 4th Furlong and Oakland was found to be 6.0 which is below the Indian Specification for Drinking Water and WHO Guidelines for Drinking Water Quality (1984).

Electrical Conductivity

Electrical Conductivity was measured using Conductivity-TDS Meter 307 (Systronics). Water sample was taken in a 50 ml beaker and the conductivity cell

was immersed in the water samples and the conductivity was recorded.

The conductivity was found out to between 124-214 µs/cm. The minimum value was found at Station 8 (Laban, Civil Hospital) and the maximum was found out to be at Station 3 (Bishnupur) (Table - 1).

Conductivity is a good measure of the total dissolved solids (viz. Ca, Mg, Na, K, carbonate, bicarbonate, sulphate, chloride etc.). The conductivity values of the drinking water samples were within the permissible limit of all the stations.

Total Dissolved Solid:
The Total Dissolved Solid was determined with the help of the data of variation in total dissolved solids is depicted in the Fig. 7 and the Table 1. Total dissolved solids varied between 110.36-156.50 mg/1. The lowest value was found in Station 6 (Jail Road) and the highest was found in Station 8 (Laban, Civil Hospital).

Dissolved solids denote mainly the various kinds of minerals present in water, in natural waters dissolved solids are composed mainly of carbonatesm bicarbonates, chlorides, sulphates, phosphates and nitrates and nitrates of calcium, magnesium, sodium, potassium, iron and manganese etc. Concentration of dissolved solids is an important parameter in drinking water at higher concentration and also reduce its potability.

Turbidity:
Turbidity was measured by Nephelometric method using the Digital Turbidity Meter 331 (Systronics). Turbidity was measured by taking 50ml of water sample in cuvet tune and then the reading was taken from the Nephelometer.

The turbidity values found in the sampling sites is shown in Table 1 which ranges from 2.50 NTU – 7.20 NTU. The highest was recorded in Station 2 (Bara Bazar), Station 9 (Mawiong), Station 12 (4^{th} Furlong) and Station 13 (Oakland) and the lowest was recorded in Station 17 (Pasteur's Institute).

Chloride:
Chloride content of the water samples was estimated by titrimetric method. 50 ml sample was taken in a conical flask and 1 ml K_2Cr_2O7 was added and titrated against 0.02 N $AgNO_3$. Silver nitrate reacts with chloride get precipitated, free silver ions react with chromate to form a reddish brown colour.

The data of variation in chlorides is shown in Table 1. The chloride value recorded varied between 22.40 – 73.84 mg/l. The lowest value was found in Station 17 (Pasteur's Institute) and the highest value was found out at Station 1 (Naspati Giri).

Alkalinity:
Alkalinity was measured by titrating water samples against 0.2N H_2SO_4.50 ml water sample was taken in a conical flask; 1 ml of phenolphthalein and 2-3 drops of methyl orange was added into the sample and titrated against 0.2 N H_2SO_4.

The alkalinity value recorded in between 16.2-40mg/l. The minimum value found was 16.2 mg/l at Station 8 (Laban, Civil Hospital) and the maximum value found was at Station 10 (Laitumkhrah). (Fig. 8)

The alkalinity values of the drinking water samples were within the permissible limit for all the stations, the recommended alkalinity value for drinking water purpose is 250 mg/l. most of the alkalinity in natural water is formed due to dissolution of CO_2 in water. Alkalinity in itself is not harmful to human beings still the water supplies with less than 100mg/l are desirable for domestic use.

Conductivity:
The conductivity was found out to be between 124-214 µs /cm. The minimum value was found at Station 8 (Laban, Civil Hospital) and the maximum was found out to be at Station 3 (Bishnupur, Last Stop). (Table – 1)

Conductivity is a good measure of the total dissolved solids (viz., Ca, Mg, Na, K, carbonate, bicarbonate, sulphate, chloride etc.). The conductivity values of the drinking water samples were within the permissible limit of all the stations.

Iron:
Iron was estimated by taking 50ml water sample in a 100 ml beaker and to it l ml of hydroxyl amine and 2 ml of hydrochloric acid was added. Then it was allowed to boil in a hot plate till the volume of the sample was reduced to half of the total volume. It was then cooled and subsequently 10ml of ammonium acetate and 4 ml of Phenonthroline were added. Finally, the sample was diluted to 100 ml with distilled water. The absorbance was then recorded at 510 nm in a spectrophotometer.

The data of variation in iron is depicted in the Fig. 9. The iron value recorded varied between 0.102 – 0.184 mg/l. The minimum value was observed in Station 6 (Jail Road) and the maximum value was observed at Station 3 (Bishnupur, Last Stop) and Station 13 (Oakland).

The describe limit of iron recorded for all the drinking sampling sites, were within the prescribed limits of the Indian Specifications for Drinking Water, IS: 10500 and WHO Guidelines for Drinking Water Quality (1984).

Nitrate:
The estimation of nitrate was carried out by Phenol Disulphonic Acid (PDA) Method. 5 ml of the water sample was taken and 5 drops of $AgSO_4$ was added in a crucible bowl and allowing it to evaporate to dryness in a water bath. The surface of crucible bowl was scratched with a glass rod by adding 2ml of PDA and a little amount of distilled water. Then it was proured in a 50 ml cuvet and diluted to 50 ml distilled water. The final reading was taken by placing the sample in cuvet and placed inside the spectrophotometer at a wavelength of 410 nm. The reading was taken accordingly.

The data of variation in nitrate is shown in Table 1. The nitrate value recorded varied between 0.70 – 1.2 mg/l. The minimum value was observed in Station 11 (Bonphail road) and the maximum value was observed at Station 17 (Pasteur's Institute).

The desirable limit of nitrate recorded for all the drinking sampling sites, were within the prescribed limits of the Indian Specifications for Drinking Water, IS: 10500 and Who Guidelines for Drinking Water Quality (1984).

Calcium
The estimation of calcium was carried out taking 20ml of the water sample in a beaker and 1 ml of 0.1N NaOH was added. Then 100 mg of murexide indicator was added where a pink colour develops. It was then titrated against 0.1N EDTA solution until the pink colour changes to purplish blue.

The data of variation in calcium is shown in Table 1. The calcium value recorded varied between 4.5 – 16.00 mg/l. The minimum value was observed in Station 17 (Pasteur's Institute) and the maximum value was observed at Station 1 (Naspati Giri) and Station 11 (Bonphail Road).

The describe limit of calcium recorded for all the drinking sampling sites, were within the prescribed limits of the Indian Specifications for Drinking water, IS: 10500 and WHO Guidelines for Drinking Water purpose is 75 mg/l (2004).

Magnesium:
The estimation of magnesium was carried out after the determination of the volume used by EDTA in calcium determination and also the volume of EDTA used in hardness ($Ca^{++} + Mg^{++}$) determination. Calcium and magnesium form a complex of wine red colour with Eriochrome Black T indicator at pH 10.0. The EDTA has got a stronger affinity for Ca^{++} and Mg^{++} the former complex is broken down and a new complex of blue colour is formed. The value of Mg^{++} can be obtained by subtracting the value of calcium form the total of $Ca^{++} + Mg^{++}$.

The data of variation in magnesium is shown in Table 1. The magnesium value recorded varied between 5.0 – 17.6mg/l. The minimum value was observed in Station 17 (Pasteur's Institute) and the maximum value was observed at Station 6 (Jail Road).

The desirable limit of magnesium recorded for all the drinking sampling sites, were within the prescribed limits of the Indian Specifications for Drinking Water, IS: 10500 and WHO Guidelines for Drinking Water Quality (1984).

Dissolved Oxygen:
The estimation of dissolved oxygen was determined by Modified Winkler's Iodometric Method. Water samples for estimation of dissolved oxygen were collected in a BOD bottle of 300 ml capacity without allowing any agitation of water while collecting or allowing aeration through contact with the air. Completely filled bottles were stopped while the bottle was still immersed. DO was fixed immediately after samples was collected by adding 1 ml of $MnSO_4$ and 1 ml of alkaline azide solution with the help of a pipette so that the solutions are added well below the surface of the sample.

The data of variation in dissolved oxygen is depicted in the Fig. 10 and Table 1. The dissolved oxygen value recorded varied between 3.2 – 8.2mg/l. The minimum value was observed in Station 6 (Jail Road) and the maximum value was observed in Station 17 (Pasteur's Institute).

Biological Parameter
Total Coliform Bacteria
The total coliform bacteria were determined by using multiple tube technique. The most probable number (MPN) of bacteria present in 100 ml of water samples were enumerated with the help of the MPN table.

The data of variation in total coliform bacteria is depicted in the Fig. 11 and the Table-1. The total coliform bacteria value recorded varied between 8 MPN – 58 MPN. The minimum value was observed in Station 13 (Oakland) and the maximum value was observed in Station 15 (Lady Kane College).

The desirable limit of total coliform bacteria recorded for all the drinking sampling sites, have exceeded the prescribed limits of the Indian Specifications for Drinking Water, IS: 10500 and WHO Guidelines for Drinking Water Quality (1984).

Discussion and conclusions

The results recorded during the monitoring of physico-chemical and bacteriological parameters of potable water used by the residents of Shillong area, Meghalaya. Among the parameters studied for each sample most of them complied with the guidelines values of the Indian Standards Specifications for Drinking Water, IS: 10500 and WHO Guidelines for Drinking Water Quality (1984). The only exception are the following parameters which exceeds the desirable limit and they are discussed below.

pH of the water samples of Lawmali, Jail Road and Lady Kane College was found to be slightly acidic with the value of 5.5 and the pH of Polo, Laban (Civil Hospital), Laitumkhrah, Bishnupur, Oakland was found to be 6.0 which is below the permissible limits of drinking water guidelines while the other seven water samples are within the desirable limit. The low pH values indicate that the water might be acidic and corrosive (WHO, 2004). Most natural waters are generally alkaline due to the presence of sufficient quantities of carbonates, pH of water gets drastically changed with time due to exposure to air, biological activity and temperature changes. pH of water has no direct adverse effects on health, however, a low value below 4 will produce sour taste and a higher value above 8.5, an alkaline taste. The low pH recorded may be due to the geologic formation of the aquifer or the soil.

The Dissolved Oxygen (DO) values for spring water samples were slightly below the permissible limits of WHO Water Guidelines as compared to PHE water samples. The condition in case of dissolved oxygen is highly complicated since in contrast to other pollutants, the quality of water is enhanced if it contains more oxygen. An ideal DO of 5.0 mg/l is the standard for drinking water (Bhanja and Ajoy, 2000). Low DO value in these water samples indicates that effluent and domestic sewage containing high organic pollutants have invaded the spring water which decreased the dissolved oxygen content as a result of microbial actives.

The total coliform bacteria in all the drinking water sample sources have exceeded the permissible limits as per the drinking water guidelines are concerned. The spring water source of Lady Kene College recorded the maximum number of 58 MPN/100. The presence of faecal coliform indicates a potential public health problem; because of faecal matter is a source of pathogenic bacteria and virus. The water contamination from faecal coliform bacteria is generally cause by percolation from the contamination sources (domestic sewage and septic tank) into the soil or aquifers and also because of poor sanitation. The indiscriminate land disposal waste on surface, improper disposal of solid waste, leaching of waste from the landfills areas, further aggravates the chances of bacterial contamination in spring water. Thus, the coliform group of bacteria is the principal indicator of suitability of water for domestic, industrial or other uses.

Based on the findings of this study, it can be concluded that long term and continued water quality surveillance by the Public Health Engineering Department of Meghalaya is to be done for quality assurance. One must consider the springs, stream and river as an alternative source of water supply after application of necessary treatment. Further chemical analysis particularly in respect to toxic, radioactive elements and heavy metal ions can be recommended. Public awareness, constant monitoring of the quality of water sources and proper sanitation will strengthen the possibility of providing water of better quality.

Table – 1
Physico-chemical and biological parameter variations in water of Shillong (study) area during March-April,

Sample No.	Sampling location	Temperature (^{0}C)	pH	Turbidity (NTU)	Conductivity (μmho/cm^{-1})	Dissolved oxygen (DO)	Total Dissolved Solids	Nitrate (mg/1)	Mg (mg/1)	Ca (mg/1)	Chloride (mg/1)	Total Coliform Bacteria (MNP/100ml)
1.	Naspatigiri	17	6.5	6.8	158	4.8	131.45	0.83	17.2	16	73.84	32
2.	Bara Bazar	16.2	6.5	7.2	175	4	125.29	0.71	17.3	13	34.08	44
3.	Bishnupur	15.5	6	6.8	212	3.6	142.51	0.75	16.8	15	28.4	39
4.	Laban (Kira farm)	15.5	6.2	7.2	180	4.2	150.8	0.88	15.4	12	22.72	18
5.	Lawmali	16.5	5.5	6.8	170	4	145.49	0.85	16.5	14.8	22.72	29
6.	Jail Road	17	5.5	6.4	200	3.2	110.36	0.81	17.6	13	45.44	35
7.	Polo	16.1	6	6.8	160	3.8	126.26	0.73	15.8	14	45.44	41
8.	Laban (Civil Hospital)	15.6	6	6	124	4.2	156.5	0.80	15.2	14	25	24
9.	Mawiong	16	6.5	7.2	180	4	115.53	0.79	15.2	12	22.72	44
10.	Laitumukhrah	16.5	6	7	210	3.6	120.88	0.81	16.3	11	30.2	17
11.	Bonphail road	16.6	6	6.8	190	3.8	135.53	0.70	16.6	16	34.08	15
12.	4th Furlong	17	6	7.2	161	4	142.56	0.79	16.2	14	28.4	37
13.	Oakland	16.2	6	7.2	161	4.6	128.64	0.79	16.2	14	28.4	8
14.	Dreamland	16.5	7	6.8	175	4.8	125.14	0.84	15.8	15	45.44	19
15.	Lady Kane College	16.3	5.5	6.8	165	4	139.21	0.88	15.6	14.8	28.4	58
16.	Happy Valley	17.1	7	6.2	159	4.2	127.18	0.72	16.3	10.5	34.08	17
17.	Pasteur's Institute	15.8	6.5	2.5	168	8.2	1.2	1.2	5	4.5	22.4	15

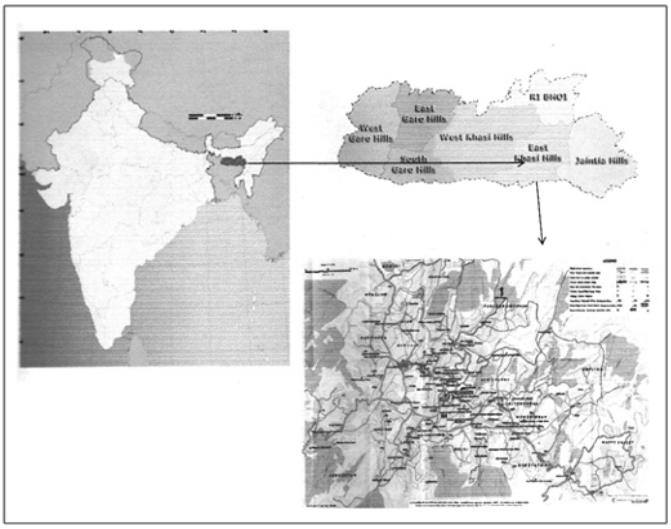

Fig.1 : Location Map of the Study Area...

Fig.2 : Station 1 showing spring water source at Naspati Giri.

Fig.3 : Station 4 showing spring water source at Laban near Kira Farm area.

Fig.4 : Station 10 showing spring water source at Laitumkhrah area.

Fig.5 : Station 12 showing spring water source at 4th Furlong.

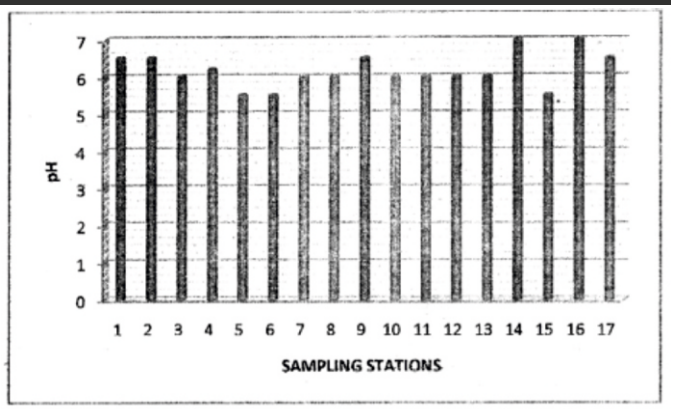

Fig.6 : Variation in Water pH of sampling stations during March-April 2014.

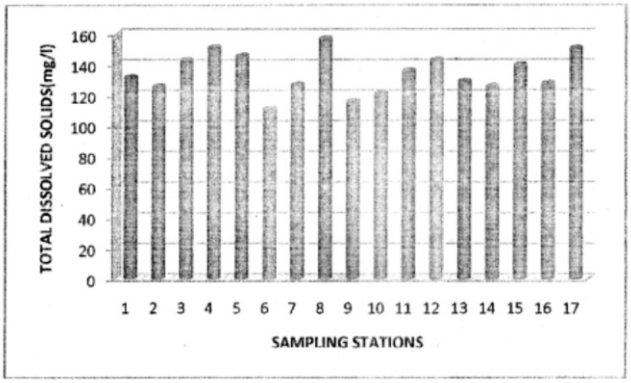

Fig.7 : Variation in Total Dissolved Solids (mg/l) of sampling stations during March-April, 2014.

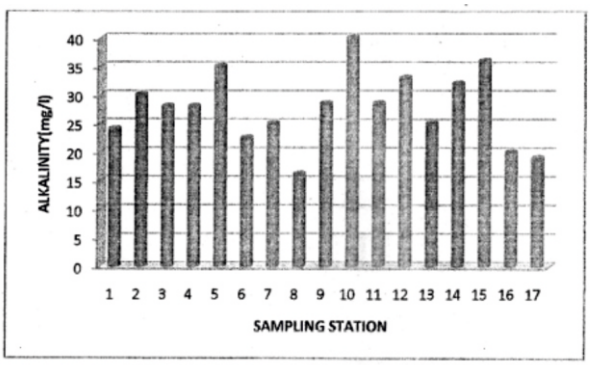

Fig.8 : Variation in Alkalinity (mg/l) of sampling stations during March-April, 2014.

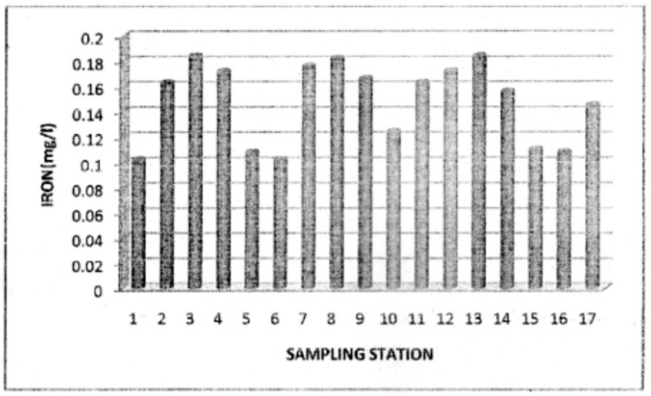

Fig.9 : Variation in Iron (mg/l) of sampling stations during March-April 2014.

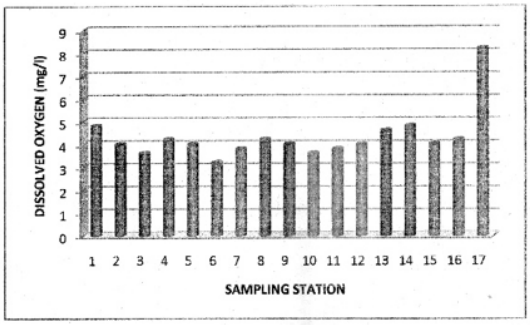

Fig.10 : Variation in Dissolved Oxygen (mg/l) of sampling stations during March-April 2014.

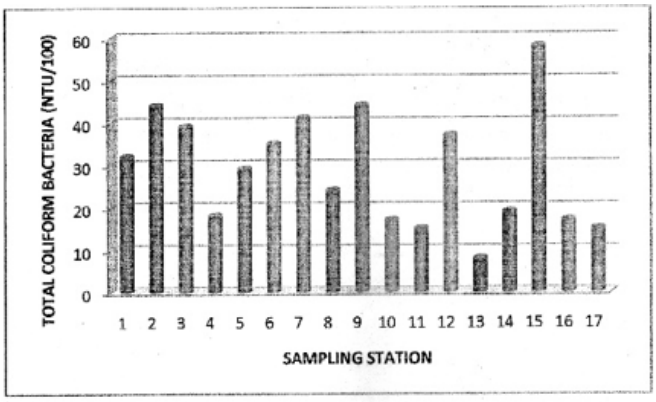

Fig.11 : Variation in total Coliform Bacteria (MNP/100) of sampling stations during March-April 2014.

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